The Effect of Environmental Temperature and Body Weight on Growth Rate and Feed:Gain of Male Broilers[1]

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ABSTRACT High environmental temperatures are detrimental to the growth and feed:gain of broilers. The objective of this research was to determine the effects of incremental differences in environmental temperature on growth and feed:gain. The data are needed for decisions about the profitability of energy inputs when managing the housing environment. In Trial 1, broiler chicks were reared as a group to 21 d on litter with constant lighting and with water and feed available for *ad libitum* consumption. They were then moved to 10 environmental chambers. Each chamber was set at a different temperature ranging from 21.1 C to 31.1 C in 1.11 C increments. Weight gain and feed:gain were determined when the broilers were 28, 35, and 42 d old. In Trials 2 and 3, broilers were placed in the environmental chambers, and weight gain and feed:gain were determined for the 42 to 49 d period. The data were analyzed statistically, and regression equations were obtained for growth and feed:gain. Equations were based on body weight and temperature, and the body weight equation was plotted as grams gain per bird per day. Feed:gain was plotted for that body weight and temperature. Body weight gain per day increased to a maximum with increasing weight and then declined. The body weight at the maximum rate of gain was inversely related to temperature. Feed:gain increased as body weight increased. Feed:gain was directly related to temperature at weights above 800 g and the effect of temperature increased as body weight increased. The data will be useful for the evaluation of various management scenarios to determine the inputs that are profitable.

(*Key words*: temperature, weight, growth, feed to gain ratio)

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INTRODUCTION

High environmental temperatures impair the growth and feed:gain of broilers (Charles, 1986). The deleterious effects are relieved in commercial flocks by evaporative cooling and increased air velocity. Growers must balance the value received from improved production and feed:gain against the cost of obtaining the improved environment. The value received is derived from incremental improvement in growth rate and feed:gain per incremental change in the environmental conditions. Feed is the most expensive component in the live production of broilers. Some feed energy is used to dissipate body heat during high temperatures (Barott and Pringle, 1946; Hurwitz *et al*., 1980). Maintaining the broiler house at more nearly optimum temperatures reduces feed cost but increases utility and water cost. Electricity is required for ventilation and evaporative cooling during hot weather, and water is required for evaporative cooling. Broiler growers routinely make decisions to balance these costs and benefits. Unfortunately, decisions regarding ventilation and evaporative cooling are usually empirical because the actual value of an incremental change in temperature is not known.

Numerous models have been developed to simulate the effects of poultry house conditions on broiler performance (Timmons and Gates, 1986; Timmons *et al*., 1995). Most of these models have used the growth and feed:gain data of Reece and Lott (1982, 1983). Changes in nutrition and the broiler's genetic potential have resulted in continuous improvement in growth rate and feed:gain since 1957 (Havenstein *et al*., 1994). More current data are needed than those provided by Reece and Lott (1982, 1983). The objective of this research was to determine the effect of environmental temperature on growth rate and feed:gain of broilers over a range of temperatures and body weights.

MATERIALS AND METHODS

Male Ross × Ross chicks were obtained from a commercial hatchery and reared on litter. Feed and

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TABLE 1. The effect of environmental temperatures on weight gain and feed:gain (F:G) of broilers, Trial 1

	21 to 28 d		28 to 35 d		35 to 42 d	
Temperature	Gain	F:G	Gain	F:G	Gain	F:G
(C)	(g)	(g:g)	(g)	(g:g)	(g)	(g:g)
21.1	573.55	1.59	697.70	1.74	740.35	1.94
22.2	552.65	1.61	663.80	1.74	637.15	2.00
23.3	573.55	1.59	698.30	1.66	670.85	1.97
24.4	504.35	1.56	623.55	1.72	622.65	1.96
25.6	490.00	1.56	666.05	1.72	634.15	2.03
26.7	456.25	1.52	661.20	1.76	650.10	2.02
27.8	505.50	1.55	641.65	1.76	571.00	2.16
28.9	528.20	1.56	616.55	1.76	603.40	2.02
30.0	486.45	1.55	629.10	1.75	584.90	2.10
31.1	599.75	1.65	547.70	1.83	492.85	2.19

water were provided for *ad libitum* consumption, and lighting was continuous. Corn:soybean meal diets were formulated to meet or exceed National Research Council (1994) requirements. Environmental chambers, as described by Reece and Deaton (1969), were used to maintain the environmental conditions during the treatment periods of three trials.

Trial 1

Male broiler chicks were placed in a controlled-environment house when they were received from the hatchery. The temperature was initially 31 C and reduced to 29 C after 3 d. At 7 d, the temperature was changed to 27 C; and at 14 d, the temperature was changed to 24 C. All broilers were on nipple waterers until they were 21 d old. Broilers were moved to 10 environmental chambers when they were 21 d old. Each chamber was arranged with two 1.14 × 1.87 m pens, and each pen was stocked with 19 broilers. One pen per chamber had a bell waterer, 33 cm in diameter. The other pen had seven nipple waterers, 20 cm apart along the side of the pen. Each of the 10 environmental chambers was set at a different temperature with the lowest at 21.1 C and the highest at 31.1 C; the others were set at 1.11 C increments between the lowest and highest temperatures. All chambers were set at 18.3 C dewpoint. Weight gain and feed:gain of all birds were determined when the broilers were 28, 35, and 42 d old.

Trials 2 and 3

Broiler chicks were placed in a controlled-environment house when they were received from the hatchery. The temperature regimen was the same as Trial 1 until 28 d and all broilers were on nipple waterers to 28 d. At 28 d, the broilers were moved to the 10 environmental chambers described in Trial 1. Each pen was stocked with 20 male broilers. The chambers were set at a daily cycle of 24-32-24 C for 2 wk. At 42 d, each chamber was set at a different temperature with the lowest at 21.1 C and the highest at 31.1 C as in Trial 1 for 7 d. All chambers were set at 18.3 C dewpoint. Weight gain and feed:gain were determined for all broilers for the 42 to 49 d period.

Statistical Analysis

The data were analyzed by PCSAS Release 6.02.[3] Regression analyses for response surfaces were used to explain body weight gain per day and feed:gain as a function of temperature and beginning weight. The response surface equation was then simplified to eliminate unnecessary terms.

RESULTS AND DISCUSSION

The raw data from Trials 1 to 3 are presented in Tables 1 and 2. All of the data are reported so that the reader may use the information for models or deriving equations for less than the entire range of the research except that the data are combined for waterer type. Temperature and age had a highly significant effect on weight gain and feed:gain. The effect of waterer type was inconsistent and is being studied further. Because the treatment conditions were the same during the data

TABLE 2. The effect of environmental temperatures on weight gain and feed:gain (F:G) of broilers from 42 to 49 d of age, Trials 2 and 3

	Trial 2		Trial 3	
Temperature	Gain	F:G	Gain	F:G
(C)	(g)	(g:g)	(g)	(g:g)
21.1	721.5	2.13	662.0	2.11
22.2	689.0	2.36	666.0	1.99
23.3	699.0	2.10	656.0	2.13
24.4	678.5	2.16	615.5	2.18
25.6	703.0	2.50	559.5	2.37
26.7	562.5	2.30	567.0	2.35
27.8	571.0	2.85	501.5	2.40
28.9	548.0	2.74	463.0	3.55
30.0	518.0	2.76	434.5	2.82
31.1	452.0	2.71	372.5	2.97

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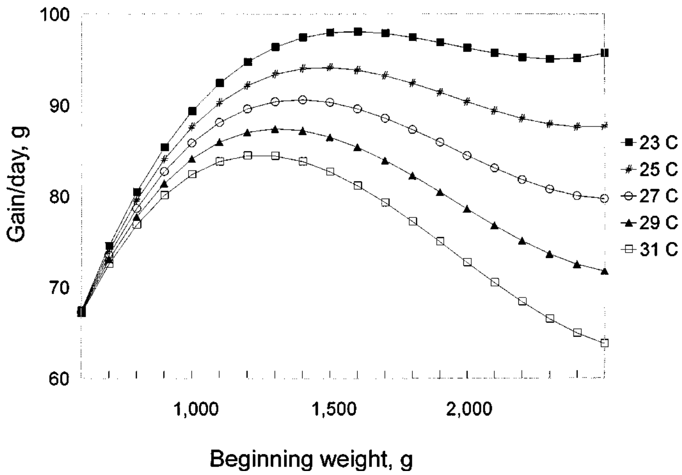

FIGURE 1. The effect of environmental temperature on daily body weight gain by broilers. The values are derived from regression analysis of data from Trials 1 to 3.

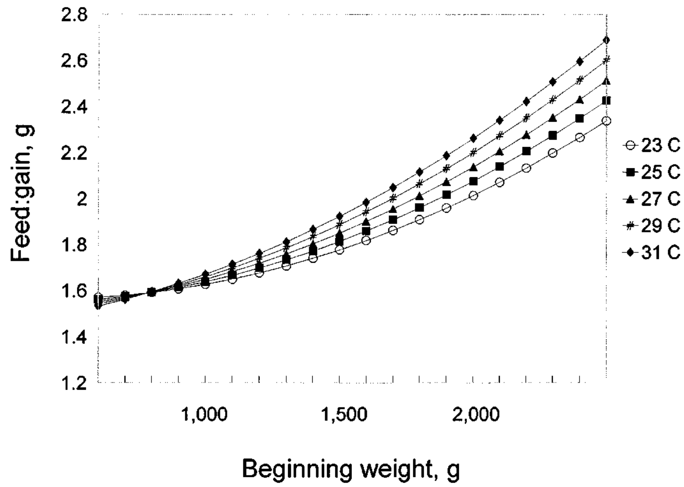

FIGURE 2. The effect of environmental temperature on instantaneous feed:gain by broilers. The values are derived from regression analysis of data from Trials 1 to 3.

collection periods for all three trials, the growth and feed:gain data from all three trials were analyzed by regression analysis, and equations were calculated to best fit the data. The resulting equation for daily weight gain was:

$$G = -31.797 + 1.2071T + 0.21457BW - 8.852 \times 10^{-5}BW^2 + 1.51 \times 10^{-8}BW^3 - 2.0772 \times 10^{-3}TBW$$

where G = gain per day, grams per day; T = environmental temperature, Celsius; and BW = body weight, grams ($r^2 = 0.81$). Using this equation, predicted daily gains for five temperatures were plotted as shown in Figure 1. The warmer temperatures were increasingly detrimental to gain as weight increased. The equations reported in this paper are based on body weight rather than age, so that they will be more useful after future improvements in growth.

The equation for feed:gain was:

$$FC = 2.0512 - 2.007 \times 10^{-2}T - 7.226 \times 10^{-4}BW + 1.7361 \times 10^{-7}BW^2 + 2.5564 \times 10^{-5}TBW$$

where FC = feed:gain in grams of feed consumed per grams of BW gain; ($r^2 = 0.93$). The data show that at 800 g and greater, the optimum feed:gain was obtained at the lowest temperature (Figure 2). This equation gives the instantaneous feed:gain rather than the usual ratio for a specific period of time, making the equation useful for determining the profitability at that time.

The data reported in this paper are useful for decision making within the ranges of temperature used in the trials, but one must be careful to not extrapolate beyond those ranges. Research is needed to expand the range of temperatures and to obtain data for females. The effect of relative humidity has not been studied.

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